

**From:** Hackett, John/DEN [John.Hackett@jacobs.com]  
**Sent:** Wednesday, March 11, 2020 4:37 PM  
**To:** Stoick, Paul T CIV USN (USA) [paul.stoick@navy.mil]; Roddy, Elizabeth A CIV USN NAVFAC SW SAN CA (USA) [elizabeth.rodgy@navy.mil]  
**CC:** Liscio, Matthew P CIV USN NAVSEA DET RASO VA (USA) [matthew.liscio@navy.mil]; Henderson, Kim/SDO [Kimberly.Henderson@jacobs.com]; Holbert, Charles/SLC [Charles.Holbert@jacobs.com]  
**Subject:** [Non-DoD Source] RE: Clarification on additional information for Background Report  
**Attachments:** Secular\_Equilibrium\_Results.xlsx

Paul/Liz,

Our proposed response to Wayne's email is below. The attached spreadsheets summarize the results of the additional testing that was performed. Please let us know if you have any questions – thanks!

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For the longer-lived radionuclides in the uranium decay series (U-238, half-life of 4.5E9 yr; U-234, half-life of 2.4E5 yr; Th-230, half-life of 7.7E4 yr; Ra-226, half-life of 1,600 yr), true secular equilibrium may not be present in the Hunters Point soil for the following reasons:

- Secular equilibrium resulting in 1 to 1 ratios of the long-lived parent and progeny radionuclides in the uranium decay series requires an environmental system that has been closed for hundreds of thousands of years (e.g., mineralized rock)
- The soil at HPNS originated from various backfill sources with different geologies
- Backfill occurred within the past 100 years, and soil has been repeatedly worked throughout that time, exposing the soil to various physical and chemical transport mechanisms that may result in disequilibrium

In addition, the concentration levels observed at HPNS are low relative to the uncertainty of the analytical method. This results in potential sources of error when comparing the uranium series results from individual samples (as described in Section 5.4 and Appendix L of the Draft RBA Report).

To address this error, additional statistical evaluation was performed using the populations of radionuclide data from each RBA. As shown in the attached tables, the results for each analysis from all the samples in a data grouping (RBA-1 Surface, RBA-1 Subsurface, etc) were compared using the Kruskal-Wallis analysis of variance test. A p-value greater than 0.05 indicates that there is not a significant difference between the populations. If the Kruskal-Wallis test identified that at least one of the populations was statistically significant (p-value less than 0.05), then the populations of each individual nuclide was compared with the others in pairs (e.g., Ra-226 to Th-230, Ra-226 to U-234, etc.) using the Wilcoxon Rank Sum test.

The key observations from this additional testing are as follows:

- RBA-1: The Th-230 population is statistically different than the U-234 and U-238 populations in surface soil. There are no statistically significant differences in subsurface soil populations.

- RBA-2: The Th-230 population is statistically different than the Ra-226, U-234, and U-238 populations in surface soil. There are no statistically significant differences in subsurface soil populations.
- RBA-3: The Ra-226 population is statistically different than the U-234 and U-238 populations in surface soil. Ra-226 and Th-230 populations are statistically different than the U-234 and U-238 populations in subsurface soil.
- RBA-4: There are no statistically significant differences in surface and subsurface soil populations.
- RBA-SB: There are no statistically significant differences in surface and subsurface soil populations.

Note that while the statistical testing identified differences between populations as noted above, the practical significance of those differences is small. For example, in RBA-1, the estimated differences in population medians between Th-230, U-234, and U-238 are around 0.2 pCi/g (shown in the charts provided with the summary tables). These differences fall within the acceptable range of analytical uncertainty. This analysis supports the conclusion from the Draft Report that the relationships between long-lived uranium decay series radionuclides may be used to determine if individual results from impacted areas reflect naturally elevated conditions.

The justification for the selection of the RBA locations is described in Section 1.2 of the Draft RBA Report and Section 3.1.3 of the Soil RBA Work Plan. These areas had no known radioactive material use. Their use was not based on an assumption of secular equilibrium.

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**From:** Henderson, Kim/SDO <Kimberly.Henderson@jacobs.com>  
**Sent:** Tuesday, March 3, 2020 2:28 PM  
**To:** Hackett, John/DEN <John.Hackett@jacobs.com>  
**Subject:** FW: Clarification on additional information for Background Report

FYI, more clarification from Wayne....

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**From:** Roddy, Elizabeth A CIV USN NAVFAC SW SAN CA (USA) <[elizabeth.rodgy@navy.mil](mailto:elizabeth.rodgy@navy.mil)>  
**Sent:** Tuesday, March 3, 2020 1:02 PM  
**To:** Henderson, Kim/SDO <[Kimberly.Henderson@jacobs.com](mailto:Kimberly.Henderson@jacobs.com)>  
**Cc:** [paul.stoick@navy.mil](mailto:paul.stoick@navy.mil)  
**Subject:** [EXTERNAL] FW: Clarification on additional information for Background Report

Kim,

See below for Wayne's request on secular equilibrium info.

Very Respectfully,

Liz Roddy  
 Remedial Project Manager  
 NAVFAC BRAC PMO West  
 33000 Nixie Way

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San Diego, CA 92147  
(619) 524-5755  
[elizabeth.rodgy@navy.mil](mailto:elizabeth.rodgy@navy.mil)

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**From:** Praskins, Wayne <[Praskins.Wayne@epa.gov](mailto:Praskins.Wayne@epa.gov)>  
**Sent:** Tuesday, March 3, 2020 11:55 AM  
**To:** Roddy, Elizabeth A CIV USN NAVFAC SW SAN CA (USA) <[elizabeth.rodgy@navy.mil](mailto:elizabeth.rodgy@navy.mil)>  
**Subject:** [Non-DoD Source] RE: Clarification on additional information for Background Report

Liz –

I'm interested in any additional information the Navy can provide on why the expected 1:1 ratio was not seen and, given the results, the impact on the determination that the onsite RBAs are not impacted by Navy activities.

**Wayne Praskins** | Superfund Project Manager  
**U.S. Environmental Protection Agency Region 9**  
75 Hawthorne St. (SFD-7-3)  
San Francisco, CA 94105  
**415-972-3181**

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**From:** Roddy, Elizabeth A CIV USN NAVFAC SW SAN CA (USA) <[elizabeth.rodgy@navy.mil](mailto:elizabeth.rodgy@navy.mil)>  
**Sent:** Tuesday, March 3, 2020 10:37 AM  
**To:** Praskins, Wayne <[Praskins.Wayne@epa.gov](mailto:Praskins.Wayne@epa.gov)>  
**Subject:** Clarification on additional information for Background Report

Wayne,

Following up on our call from this morning. I should be able to send the soil type lithology details per sample to you today. Can you please clarify the details you are looking for in regards to secular equilibrium? From our call, my understanding is that you are looking for additional detail on the sample by sample comparison statistics resulting in secular equilibrium not showing a 1:1 ratio? And reasons why this could have occurred?

Very Respectfully,

Liz Roddy  
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Table 1  
**Comparison of Radioactivities of Different Isotopes in Soil at RBA-1**  
*Former Hunters Point Naval Shipyard Background Study Report*  
*San Francisco, CA*

Group	Kruskal-Wallis Test p-value	Wilcoxon Test p-value	Wilcoxon Test Adj. p-value <sup>(1)</sup>	95% CI Median Difference
<b>Surface Soil</b>				
Ra-226 - Th -230	<b>0.009</b>	0.088	0.170	---
Ra-226 - U-234		0.225	0.270	---
Ra-226 - U-238		0.118	0.177	---
Th-230 - U-234		<b>0.010</b>	<b>0.029</b>	0.038 - 0.257
Th-230 - U-238		<b>0.003</b>	<b>0.017</b>	0.067 - 0.283
U-234 - U-238		0.467	0.467	---
<b>Subsurface Soil</b>				
Ra-226 - Th -230	0.570	---	---	---
Ra-226 - U-234		---	---	---
Ra-226 - U-238		---	---	---
Th-230 - U-234		---	---	---
Th-230 - U-238		---	---	---
U-234 - U-238		---	---	---

**Notes:**

"---" = not applicable

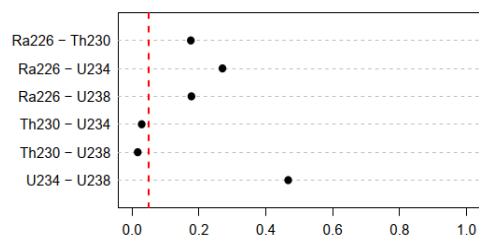
Adj. = adjusted

CI = confidence interval

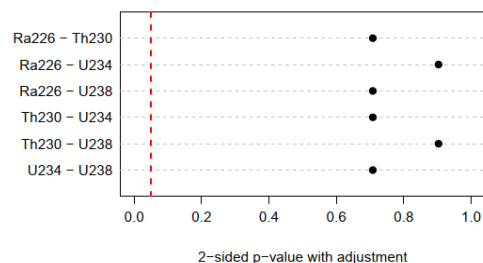
Bolded values indicate a statistically significant difference at a 0.05 significance level.

<sup>(1)</sup>Benjamini-Hochberg method used to control false discovery rate to account for multiple comparisons.

**Pairwise Wilcox Test**

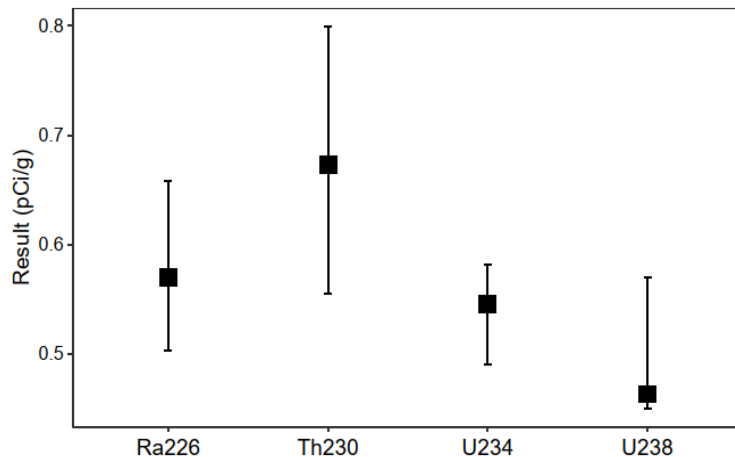


**Pairwise Wilcox Test**



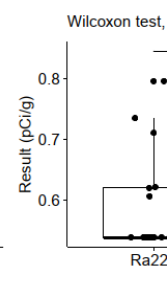
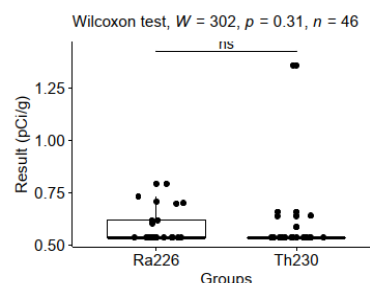
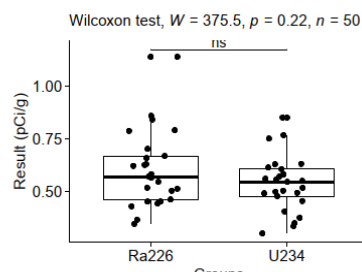
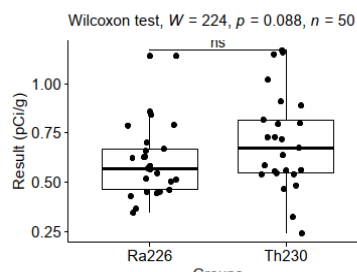
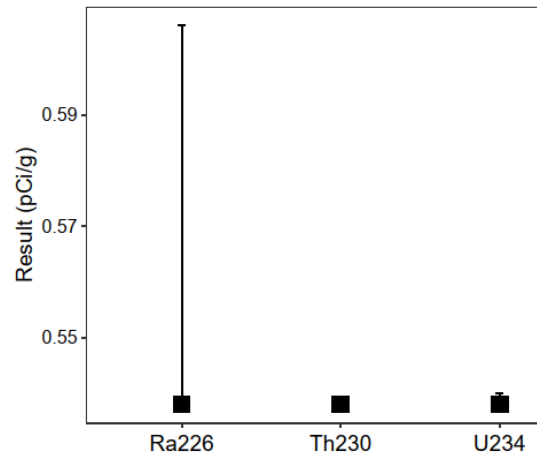
**Surface Soil**

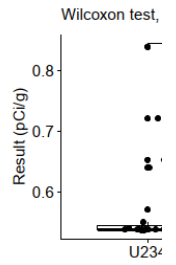
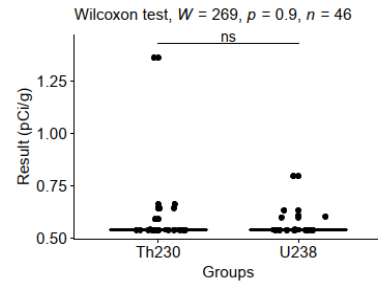
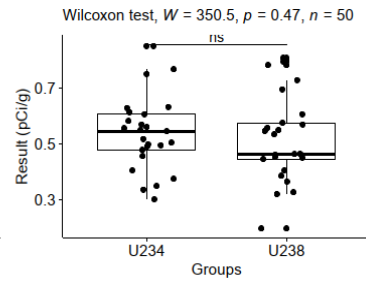
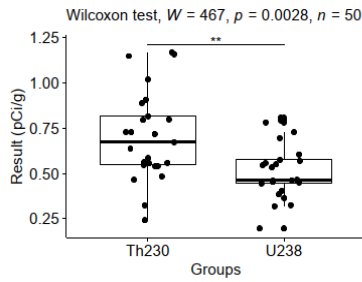
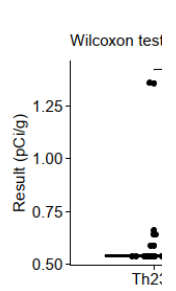
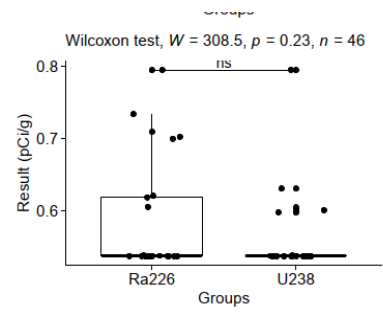
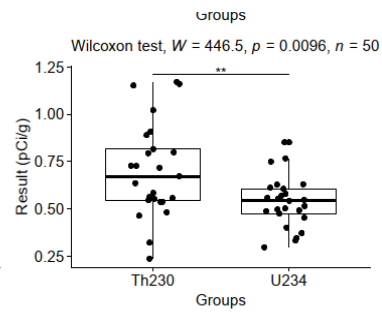
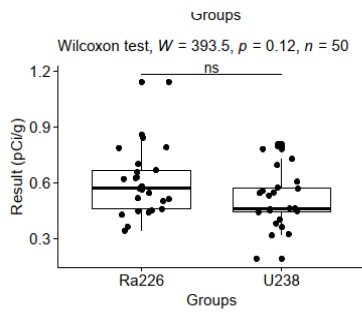
**Groupwise Median with 95% Bootstrap Confidence Interval**

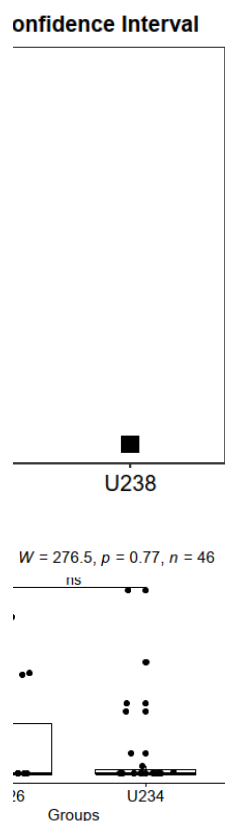


**Subsurface Soil**

**Groupwise Median with 95% Bootstrap Confidence Interval**







Groups  
t,  $W = 238$ ,  $p = 0.47$ ,  $n = 46$   
ns

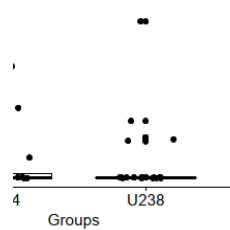
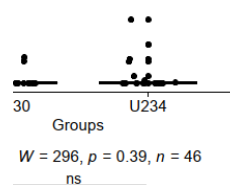




Table 2  
**Comparison of Radioactivities of Different Isotopes in Soil at RBA-2**  
*Former Hunters Point Naval Shipyard Background Study Report*  
*San Francisco, CA*

Group	Kruskal-Wallis Test p-value	Wilcoxon Test p-value	Wilcoxon Test Adj. p-value	95% CI Median Difference
Surface Soil				
Ra-226 - Th -230	0.007	0.009	0.021	(0.345) - (0.044)
Ra-226 - U-234		0.337	0.453	---
Ra-226 - U-238		0.705	0.705	---
Th-230 - U-234		0.003	0.016	0.084 - 0.375
Th-230 - U-238		0.010	0.021	0.042 - 0.338
U-234 - U-238		0.352	0.453	---
Subsurface Soil				
Ra-226 - Th -230	0.042	0.063	0.13	---
Ra-226 - U-234		0.304	0.46	---
Ra-226 - U-238		0.461	0.55	---
Th-230 - U-234		0.022	0.11	<0.001 - 1.16
Th-230 - U-238		0.035	0.11	<0.001 - 1.12
U-234 - U-238		0.662	0.66	---

**Notes:**

"---" = not applicable

"<" = less than

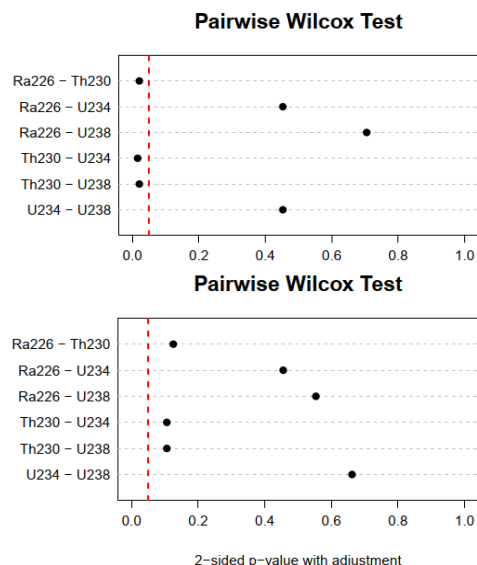
"()" = negative value

Adj. = adjusted

CI = confidence interval

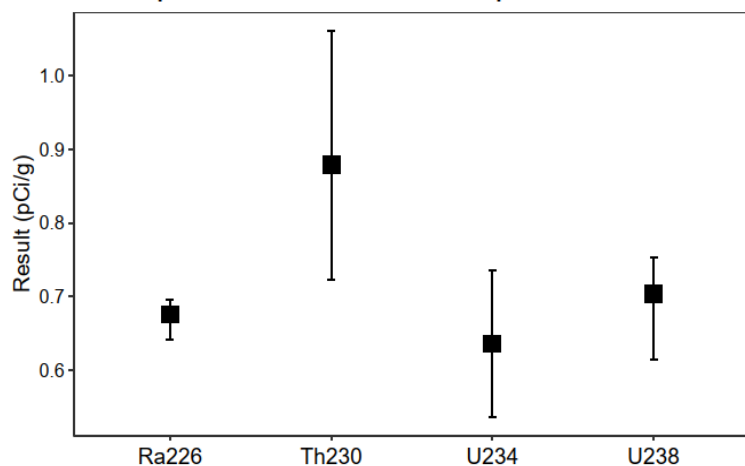
Bolded values indicate a statistically significant difference at a 0.05 significance level.

<sup>(1)</sup>Benjamini-Hochberg method used to control false discovery rate to account for multiple comparisons.

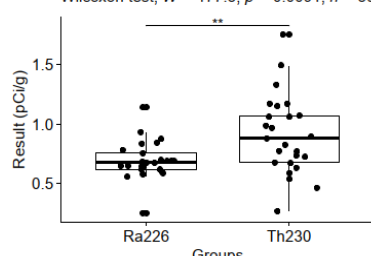


**Surface Soil**

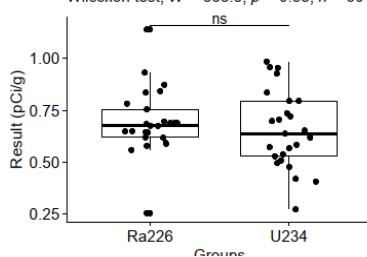
**Groupwise Median with 95% Bootstrap Confidence Interval**



Wilcoxon test,  $W = 177.5$ ,  $p = 0.0091$ ,  $n = 50$

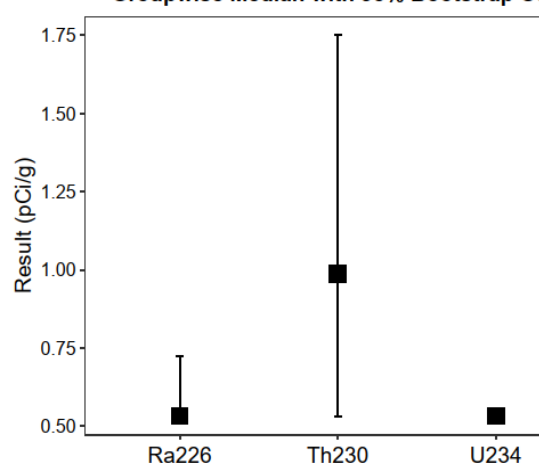


Wilcoxon test,  $W = 358.5$ ,  $p = 0.38$ ,  $n = 50$

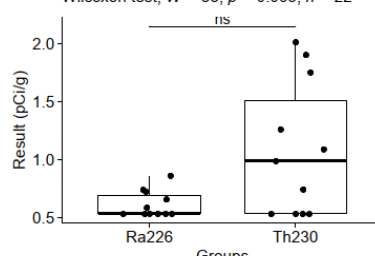


**Subsurface Soil**

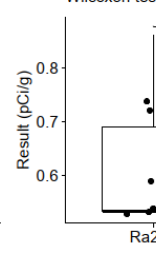
**Groupwise Median with 95% Bootstrap Confidence Interval**

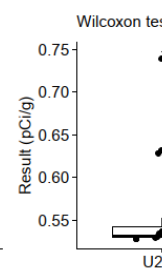
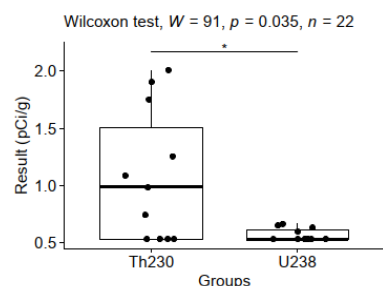
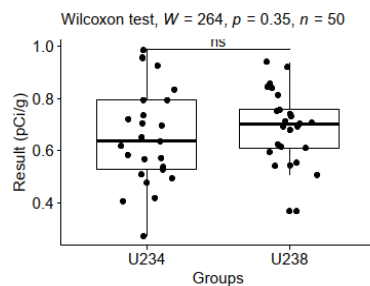
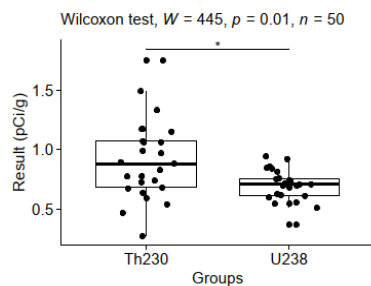
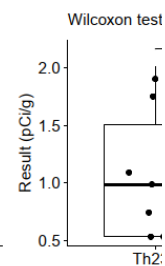
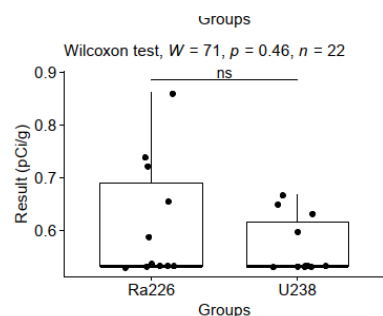
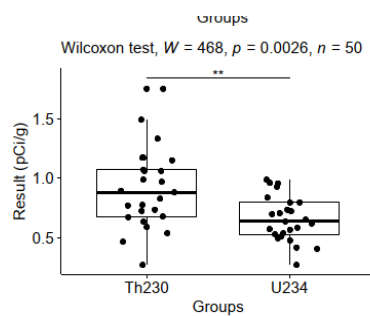
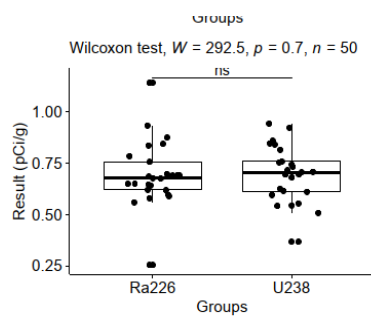


Wilcoxon test,  $W = 33$ ,  $p = 0.063$ ,  $n = 22$



Wilcoxon test

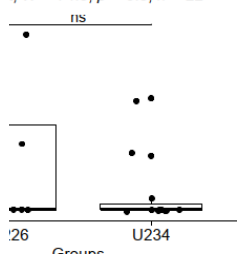




Confidence Interval

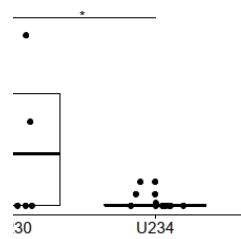


t,  $W = 74.5$ ,  $p = 0.3$ ,  $n = 22$



Groups

t,  $W = 93$ ,  $p = 0.022$ ,  $n = 22$



Groups

st,  $W = 54.5$ ,  $p = 0.66$ ,  $n = 22$

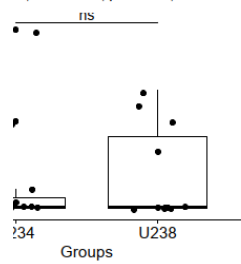


Table 3  
**Comparison of Radioactivities of Different Isotopes in Soil at RBA-3**  
*Former Hunters Point Naval Shipyard Background Study Report*  
*San Francisco, CA*

	Kruskal-Wallis	Wilcoxon	Wilcoxon	95% CI
	Test	Test	Test	Median
Group	p-value	p-value	Adj. p-value	Difference
Surface Soil				
Ra-226 - Th -230	0.005	0.286	0.343	---
Ra-226 - U-234		0.001	0.004	0.037 - 0.130
Ra-226 - U-238		0.001	0.004	0.035 - 0.115
Th-230 - U-234		0.171	0.332	---
Th-230 - U-238		0.222	0.332	---
U-234 - U-238		0.438	0.438	---
Subsurface Soil				
Ra-226 - Th -230	<0.001	0.356	0.427	---
Ra-226 - U-234		0.003	0.004	0.011 - 0.086
Ra-226 - U-238		<0.001	0.002	0.015 - 0.086
Th-230 - U-234		<0.001	0.002	0.023 - 0.134
Th-230 - U-238		<0.001	0.002	0.023 - 0.149
U-234 - U-238		0.510	0.510	---

**Notes:**

"---" = not applicable

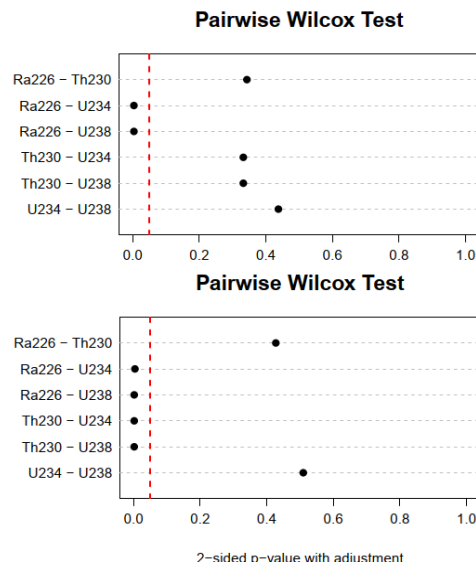
"<" = less than

Adj. = adjusted

CI = confidence interval

Bolded values indicate a statistically significant difference at a 0.05 significance level.

<sup>(1)</sup>Benjamini-Hochberg method used to control false discovery rate to account for multiple comparisons.

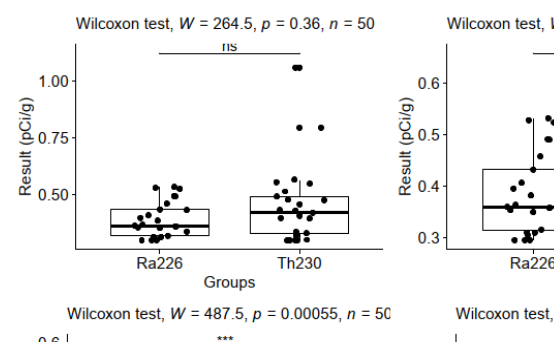
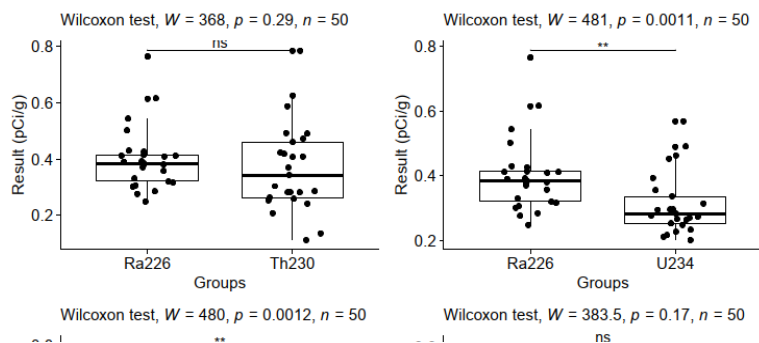
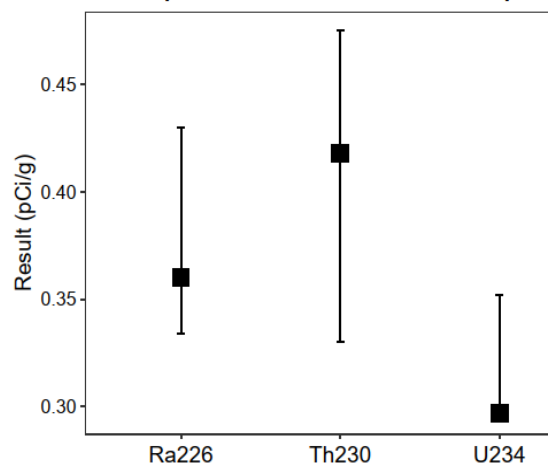
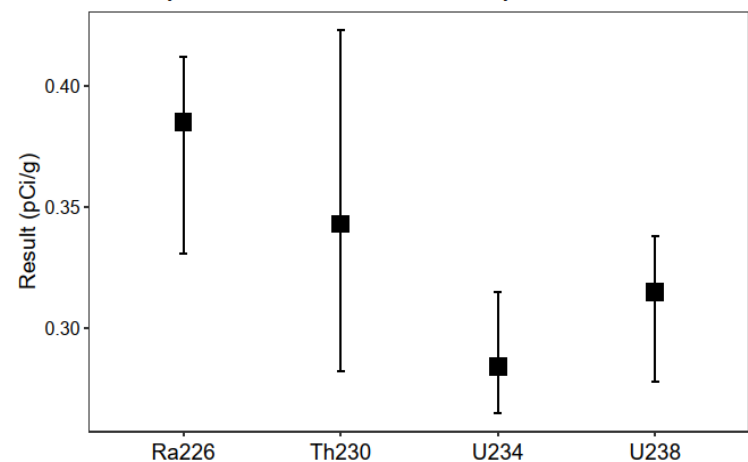


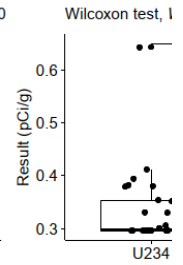
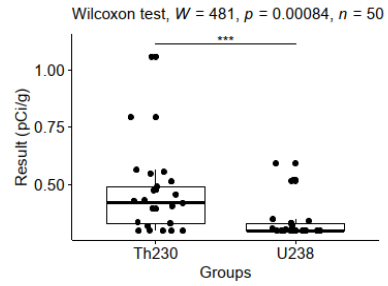
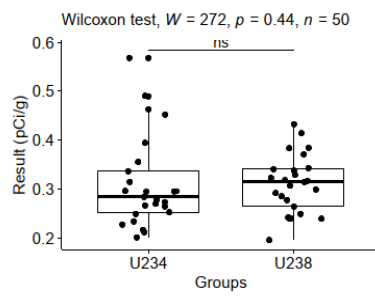
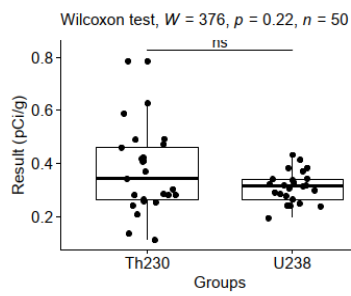
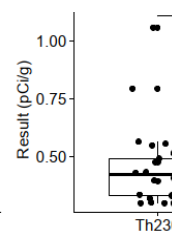
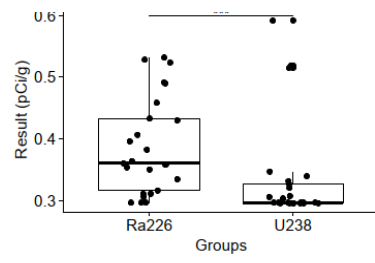
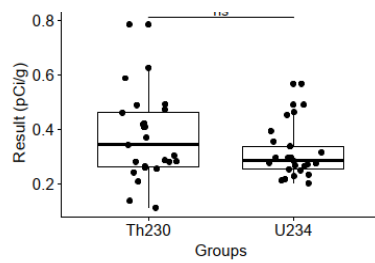
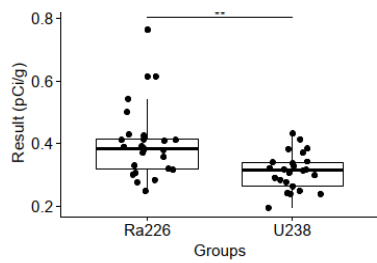
**Surface Soil**

**Subsurface Soil**

**Groupwise Median with 95% Bootstrap Confidence Interval**

**Groupwise Median with 95% Bootstrap Co**



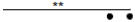




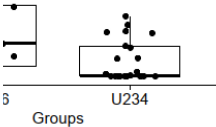
Confidence Interval



$W = 465.5, p = 0.0027, n = 50$



U234



$W = 480.5, p = 0.00095, n = 5$

\*\*\*

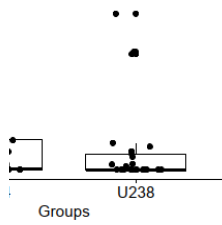
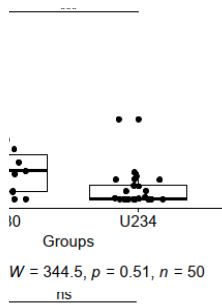




Table 4  
**Comparison of Radioactivities of Different Isotopes in Soil at RBA-4**  
*Former Hunters Point Naval Shipyard Background Study Report*  
*San Francisco, CA*

	Kruskal-Wallis	Wilcoxon	Wilcoxon	95% CI
	Test	Test	Test	Median
Group	p-value	p-value	Adj. p-value	Difference
Surface Soil				
Ra-226 - Th -230	0.448	---	---	---
Ra-226 - U-234		---	---	---
Ra-226 - U-238		---	---	---
Th-230 - U-234		---	---	---
Th-230 - U-238		---	---	---
U-234 - U-238		---	---	---
Subsurface Soil				
Ra-226 - Th -230	0.641	---	---	---
Ra-226 - U-234		---	---	---
Ra-226 - U-238		---	---	---
Th-230 - U-234		---	---	---
Th-230 - U-238		---	---	---
U-234 - U-238		---	---	---

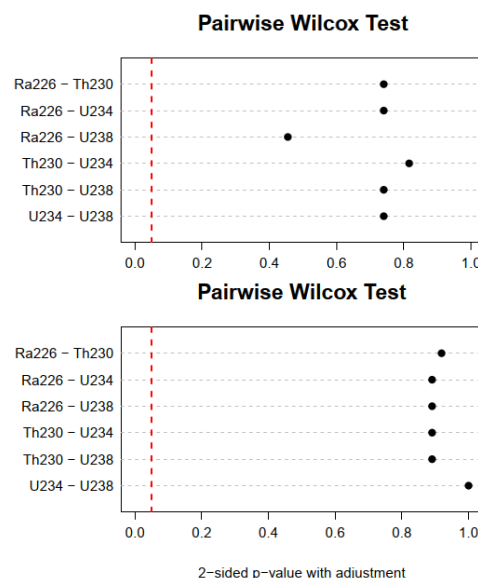
**Notes:**

"---" = not applicable

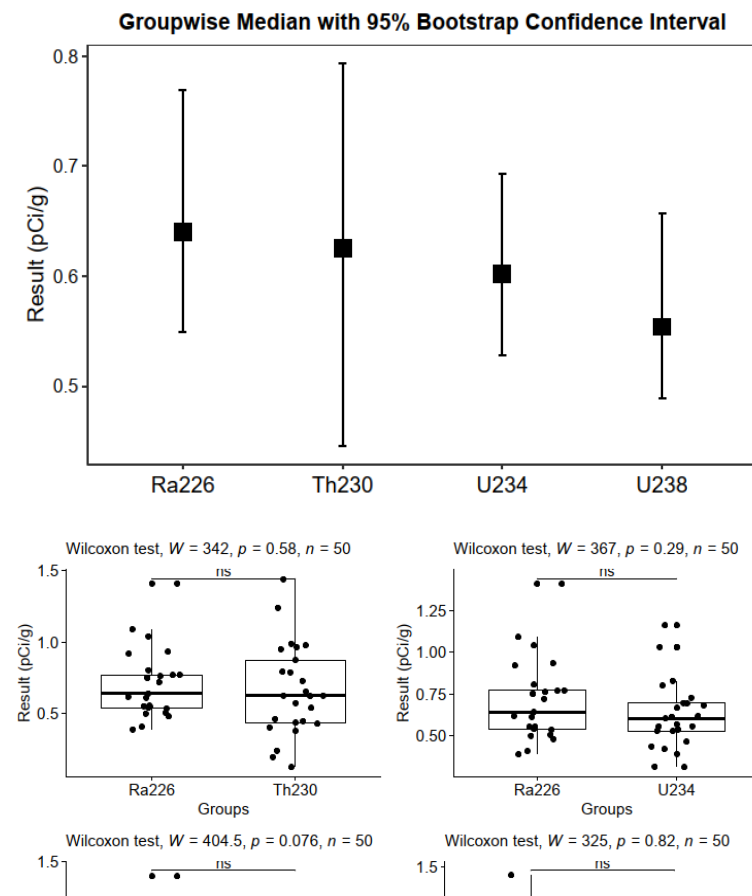
Adj. = adjusted

CI = confidence interval

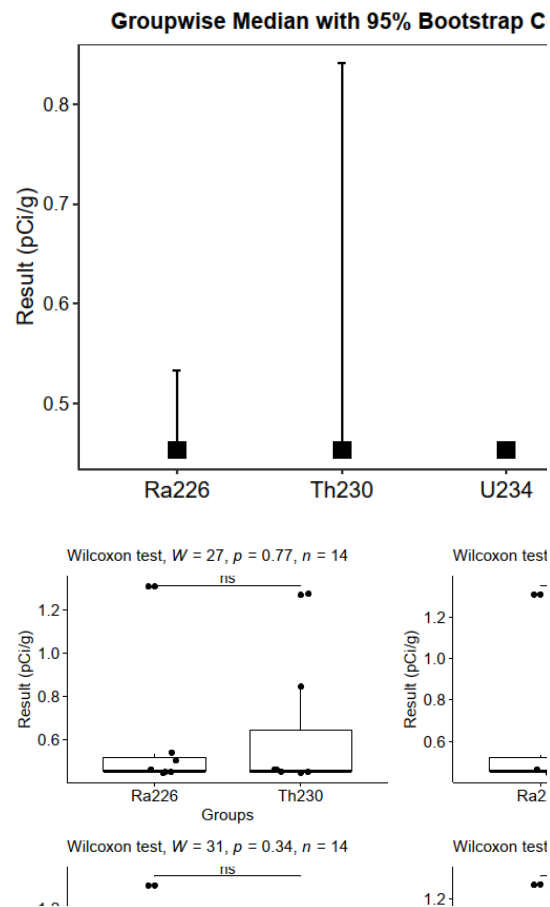
<sup>(1)</sup>Benjamini-Hochberg method used to control false discovery rate to account for multiple comparisons.

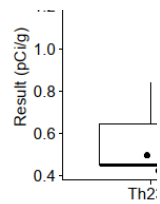
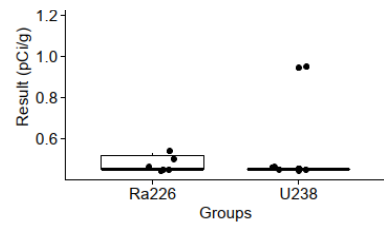
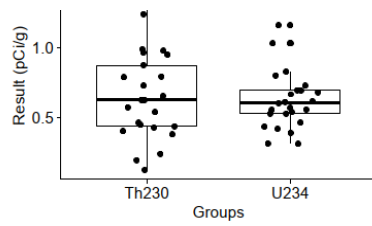
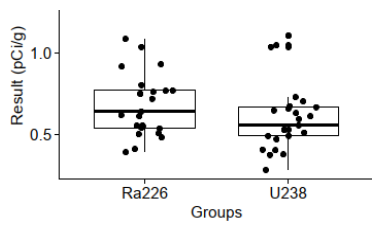


**Surface Soil**



**Subsurface Soil**



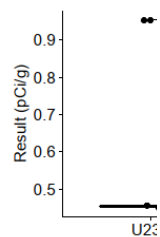
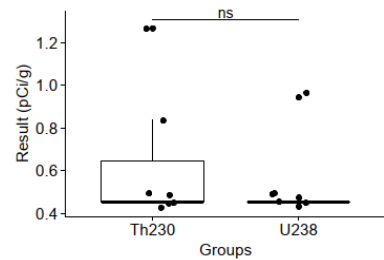
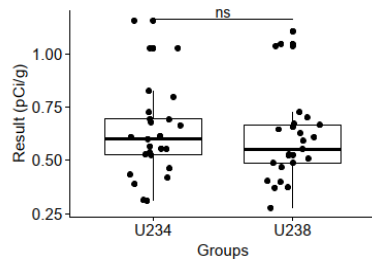
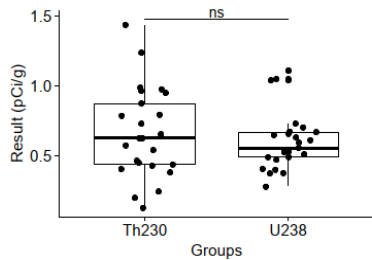


Wilcoxon test,  $W = 339$ ,  $p = 0.62$ ,  $n = 50$

Wilcoxon test,  $W = 348.5$ ,  $p = 0.49$ ,  $n = 50$

Wilcoxon test,  $W = 28$ ,  $p = 0.59$ ,  $n = 14$

Wilcoxon test



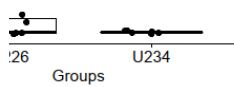
Confidence Interval



$t, W = 31, p = 0.34, n = 14$

ns

••



$t, W = 28, p = 0.59, n = 14$

ns

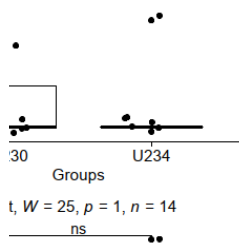


Table 5

**Comparison of Radioactivities of Different Isotopes in Soil at RBA San Bruno  
Former Hunters Point Naval Shipyard Background Study Report  
San Francisco, CA**

	Kruskal-Wallis	Wilcoxon	Wilcoxon	95% CI
	Test	Test	Test	Median
Group	p-value	p-value	Adj. p-value	Difference
Surface Soil				
Ra-226 - Th -230	0.103	---	---	---
Ra-226 - U-234		---	---	---
Ra-226 - U-238		---	---	---
Th-230 - U-234		---	---	---
Th-230 - U-238		---	---	---
U-234 - U-238		---	---	---
Subsurface Soil				
Ra-226 - Th -230	0.044	0.663	0.795	---
Ra-226 - U-234		0.029	0.096	0.004 - 0.089
Ra-226 - U-238		0.035	0.096	0.003 - 0.087
Th-230 - U-234		0.062	0.096	---
Th-230 - U-238		0.064	0.096	---
U-234 - U-238		0.829	0.829	---

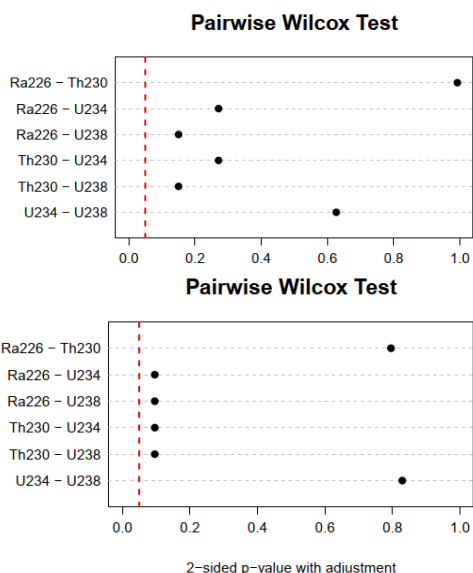
"---" = not applicable

Adj. = adjusted

CI = confidence interval

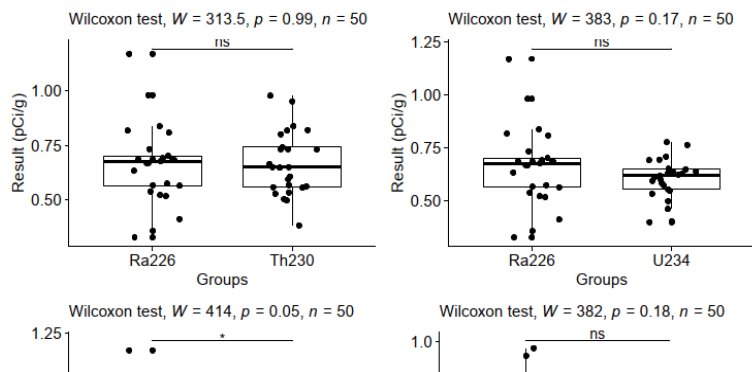
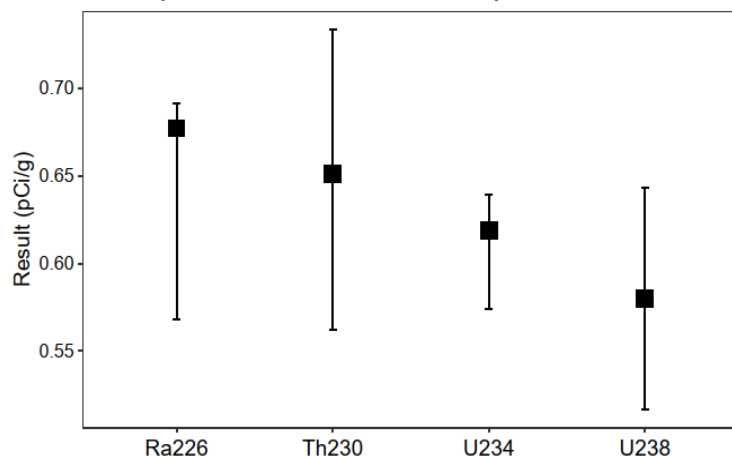
Bolded values indicate a statistically significant difference at a 0.05 significance level.

(<sup>1</sup>)Benjamini-Hochberg method used to control false discovery rate to account for multiple comparisons.



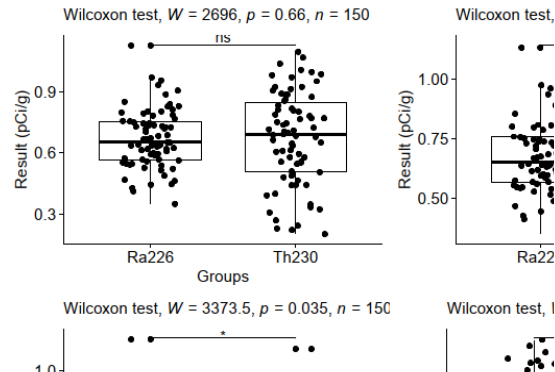
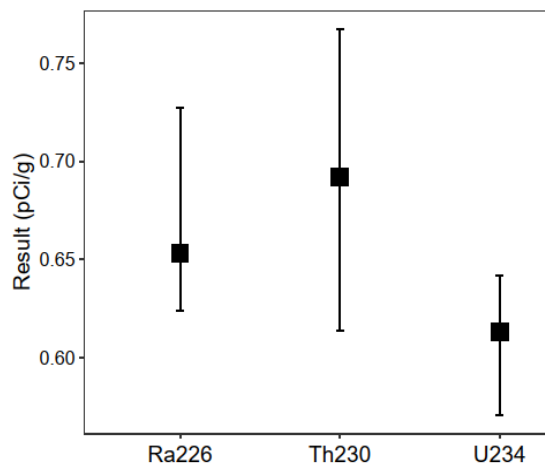
### Surface Soil

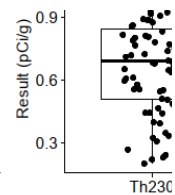
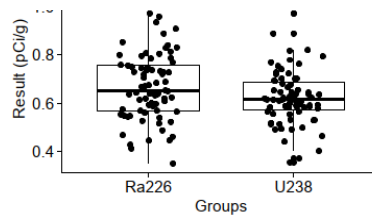
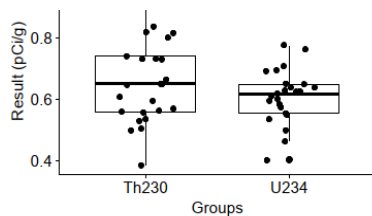
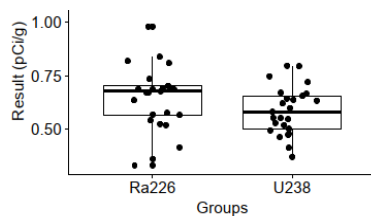
#### Groupwise Median with 95% Bootstrap Confidence Interval



### Subsurface Soil

#### Groupwise Median with 95% Bootstrap Confidence Interval



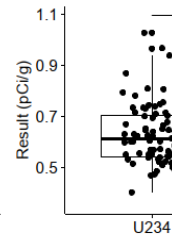
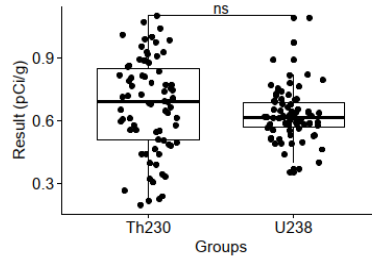
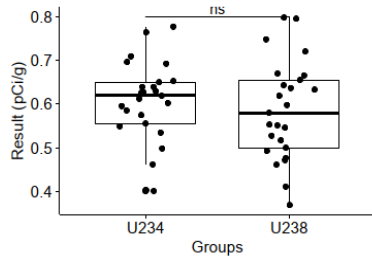
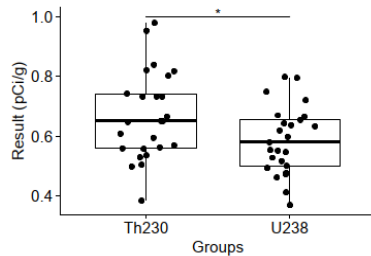


Wilcoxon test,  $W = 419$ ,  $p = 0.04$ ,  $n = 50$

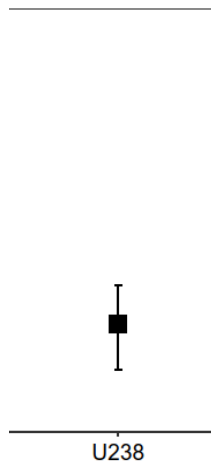
Wilcoxon test,  $W = 346$ ,  $p = 0.52$ ,  $n = 50$

Wilcoxon test,  $W = 3306$ ,  $p = 0.064$ ,  $n = 150$

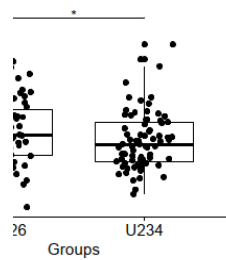
Wilcoxon test,  $W = 100$ ,  $p = 0.99$ ,  $n = 50$



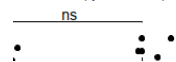
Confidence Interval

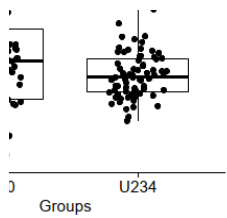


,  $W = 3395$ ,  $p = 0.029$ ,  $n = 150$



$W = 3309$ ,  $p = 0.062$ ,  $n = 150$





$W = 2754.5, p = 0.83, n = 150$

